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The KL Mix Model Applied to Directly Driven Capsules on the Omega Laser*

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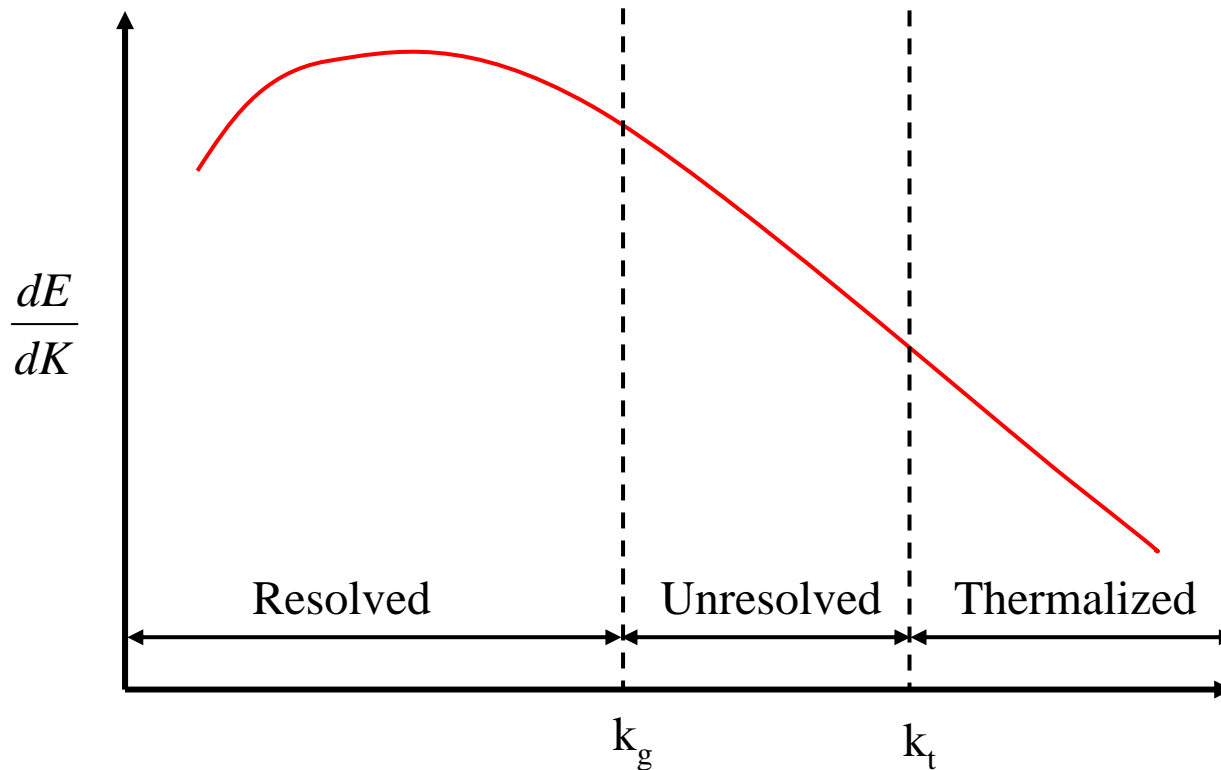
*This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

Main Points



- The coefficients of the KL mix model were set by Dimonte to match RT and RM instabilities as measured on the Linear Electric Motor (LEM).
- The KL mix model has been applied to directly-driven capsule implosions with a variety of laser energies, ablator materials, ablator thicknesses and convergence ratios.
- The KL calculations nearly match the observed Y_{DD} , Y_{DT} , Y_P , T_{ion} and implosion times for many (but not all) capsules.

The KL model characterizes sub-grid hydrodynamics with 2 variables



$$K = \int_{k_g}^{k_t} \frac{dE}{dk} dk$$

L is the characteristic
eddy size

Please see Guy Dimonte's talk on the KL equations –
LO1.00009 3:36 Wed Oct 26, 2005

All coefficients of the KL model can be derived from four numbers



- $\alpha_B = 0.07$ – Young's RT bubble coefficient
- $\theta = 0.25$ – RM exponent
- $f_{PE} = 0.50$ – Ratio of turbulent to potential energy
- $C_c = 0.$ – the compression coefficient in the L eq.

α_B inferred from LEM data is 0.06 rather than 0.07

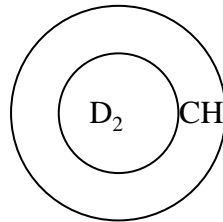
The ideal value of C_c is 1/3 rather than 0

1D Calculations with CALEICF

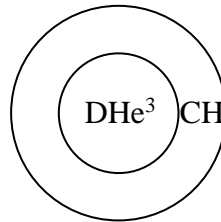


- Sn radiation transport
- Electron thermal flux limiter of 0.05
- LTE opacities from SHM
- Lee-More thermal conductivities
- Thermonuclear reactions
- MC charged particle transport
- $T+D \Rightarrow N + He4$ reactions in flight
- $He3+D \Rightarrow P + He4$ reactions in flight
- Initialize L field to 50nm on inner surface
- Initialize L field to 50-150nm on outer surface

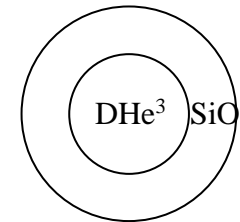
Three different types of capsules were tested



D_2 Fuel with
CH Ablator



DHe^3 Fuel with
CH Ablator

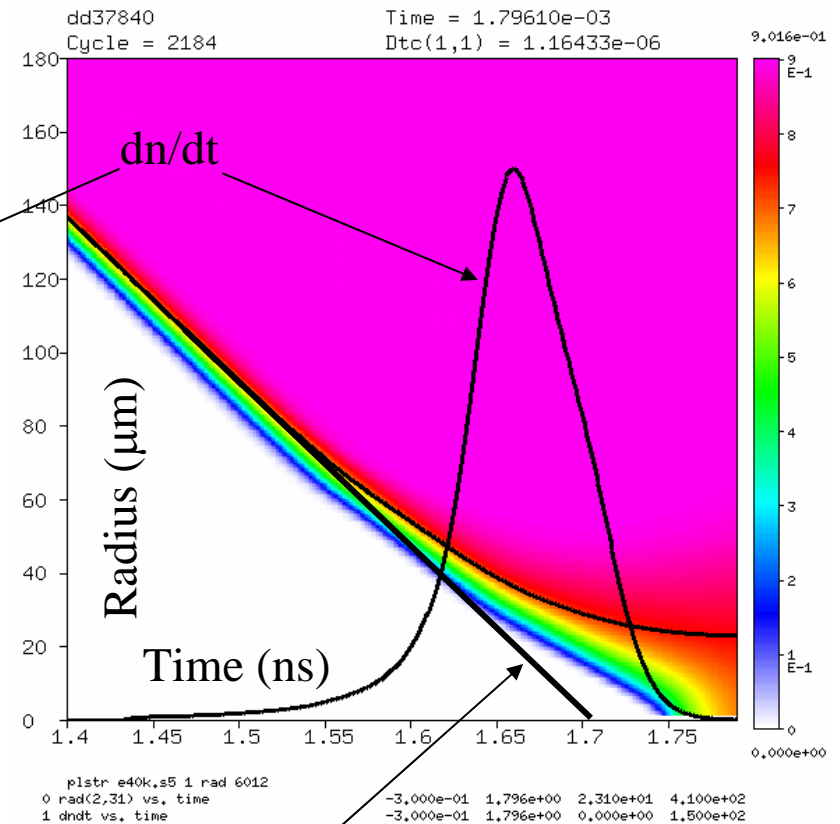
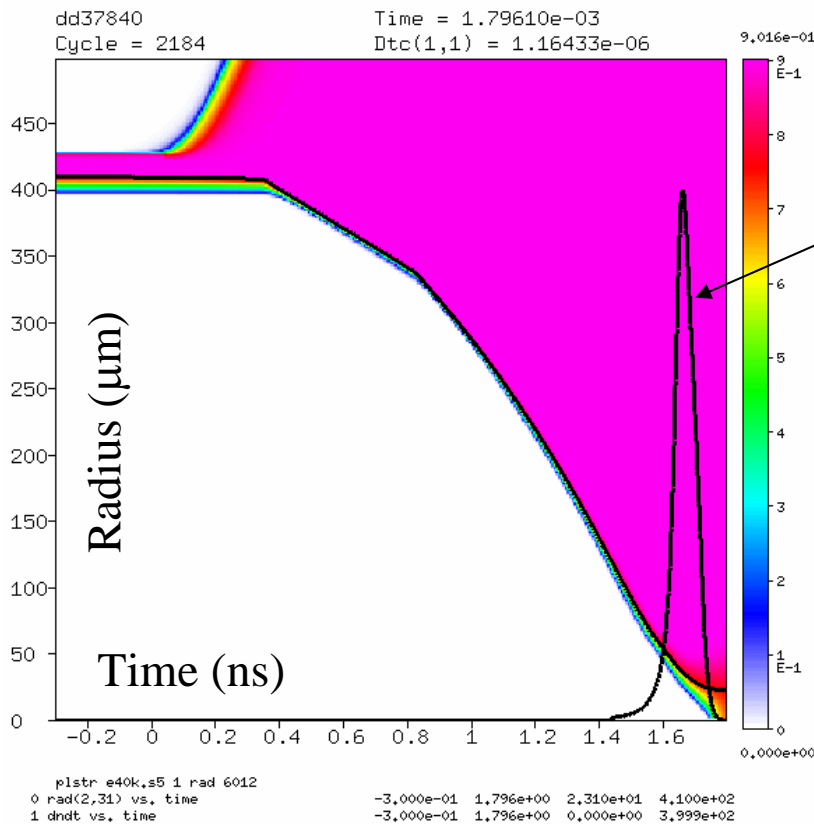


DHe^3 Fuel with
 SiO_2 Ablator

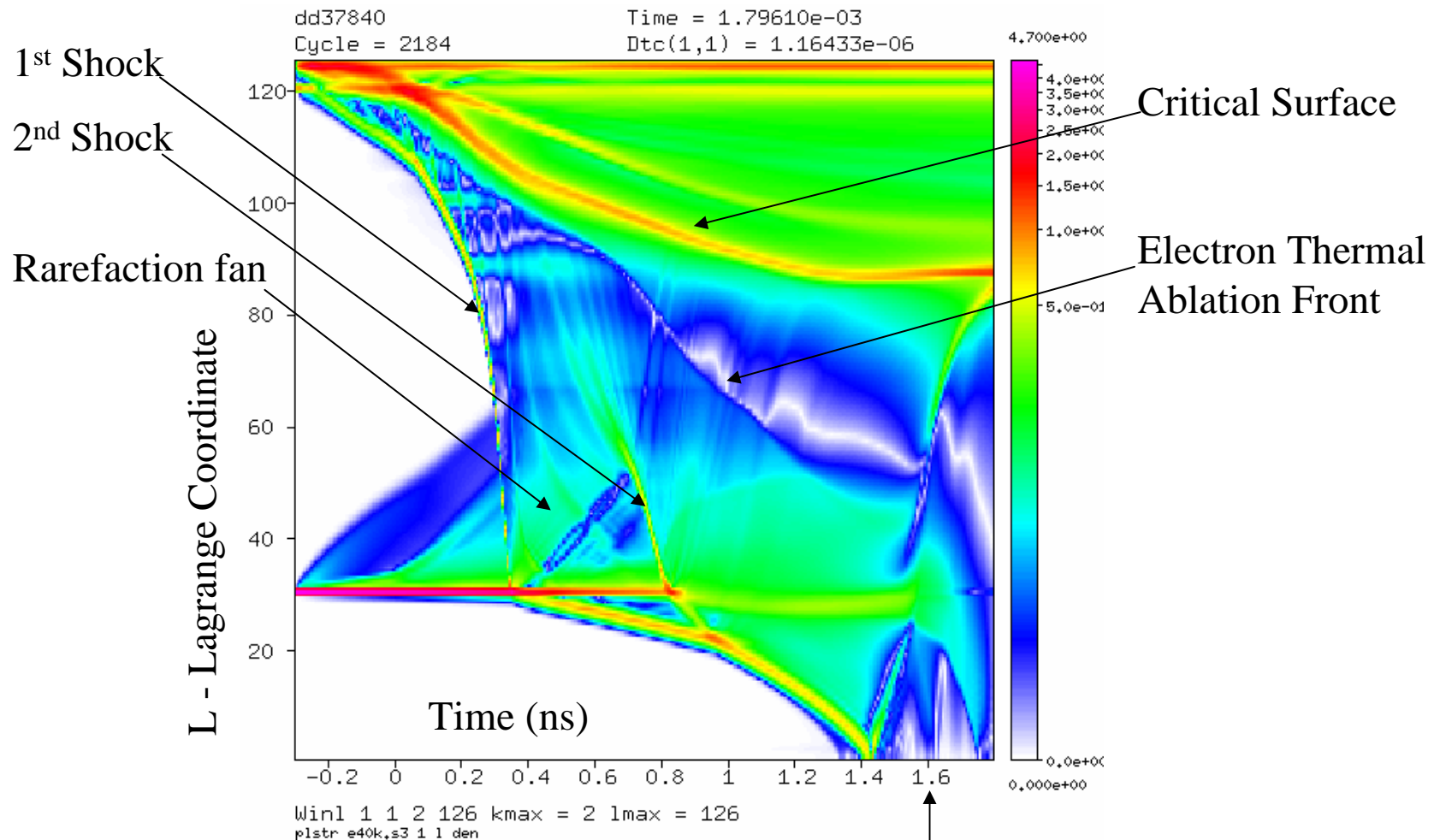
Three types of direct drive laser capsules were fired with different fuel pressures, ablator thickness and laser energies. Measured quantities include:

- 1 Primary DD neutrons and secondary DT neutrons
- 2 Primary DHe^3 protons (for D_2 fuels secondary DHe^3 protons were measured)
- 3 Ion temperatures (inferred from TOF spreading of the DD neutrons)
- 4 Implosion Time

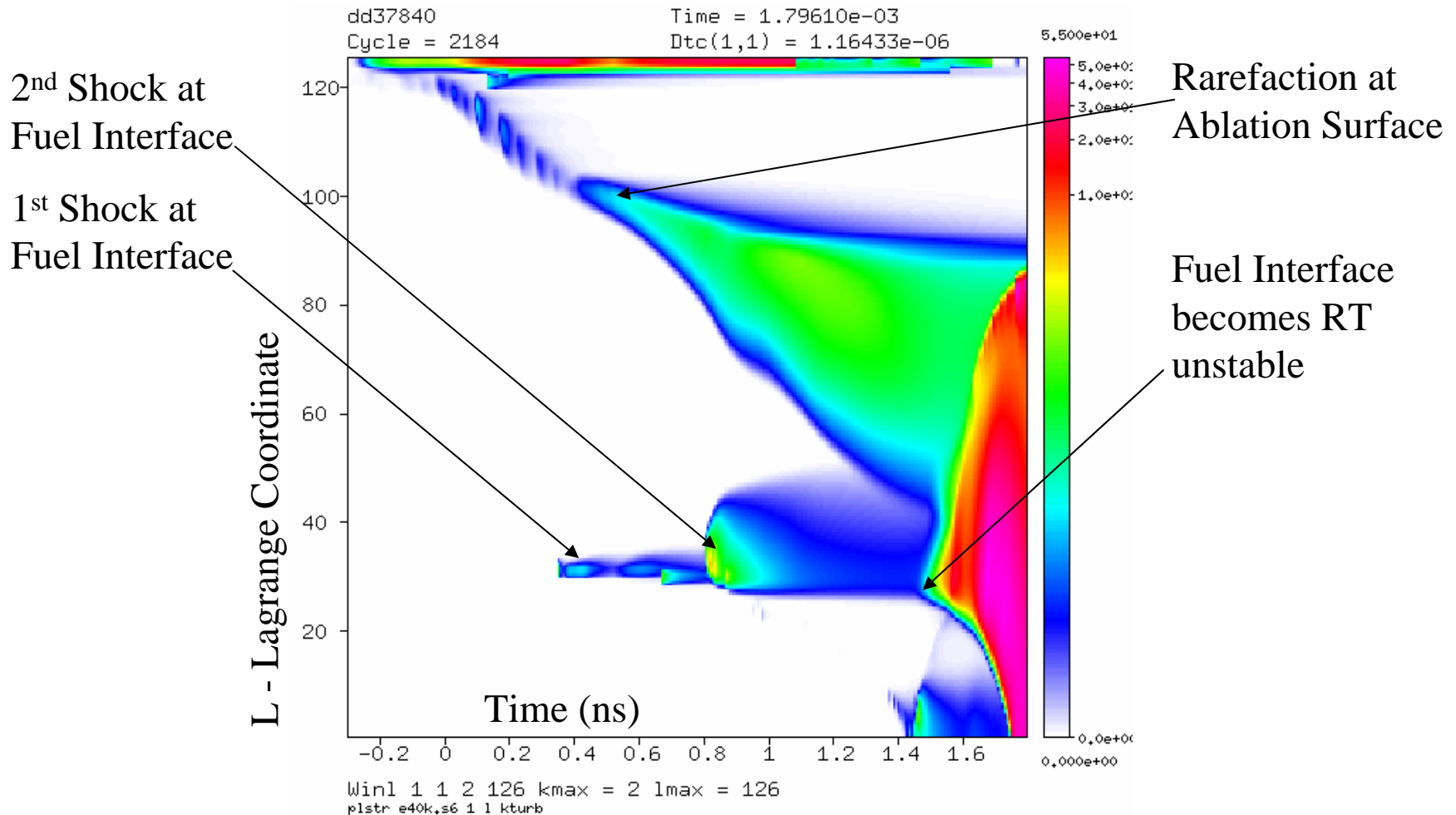
Carbon mass fraction front nearly follows the free-fall line



Streak plot of $d \log(\rho)/dL$ shows shocks, rarefactions and ablation fronts



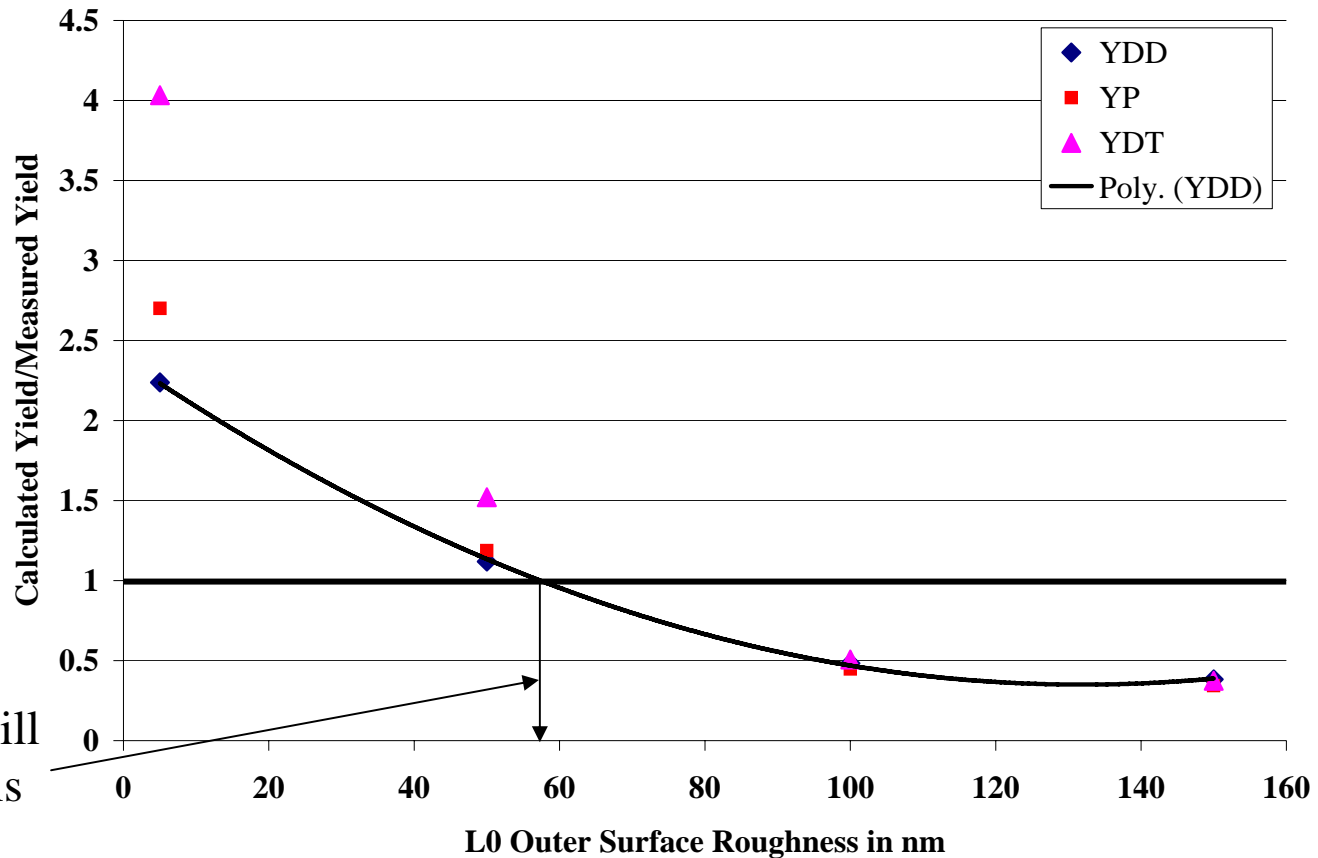
Streak plot shows turbulent energy feeds through from thermal-ablation front to fuel surface



KL model predicts instabilities near laser absorption will degrade performance. Outer surface roughness can be adjusted to match data



L0 Study for Shot 37840

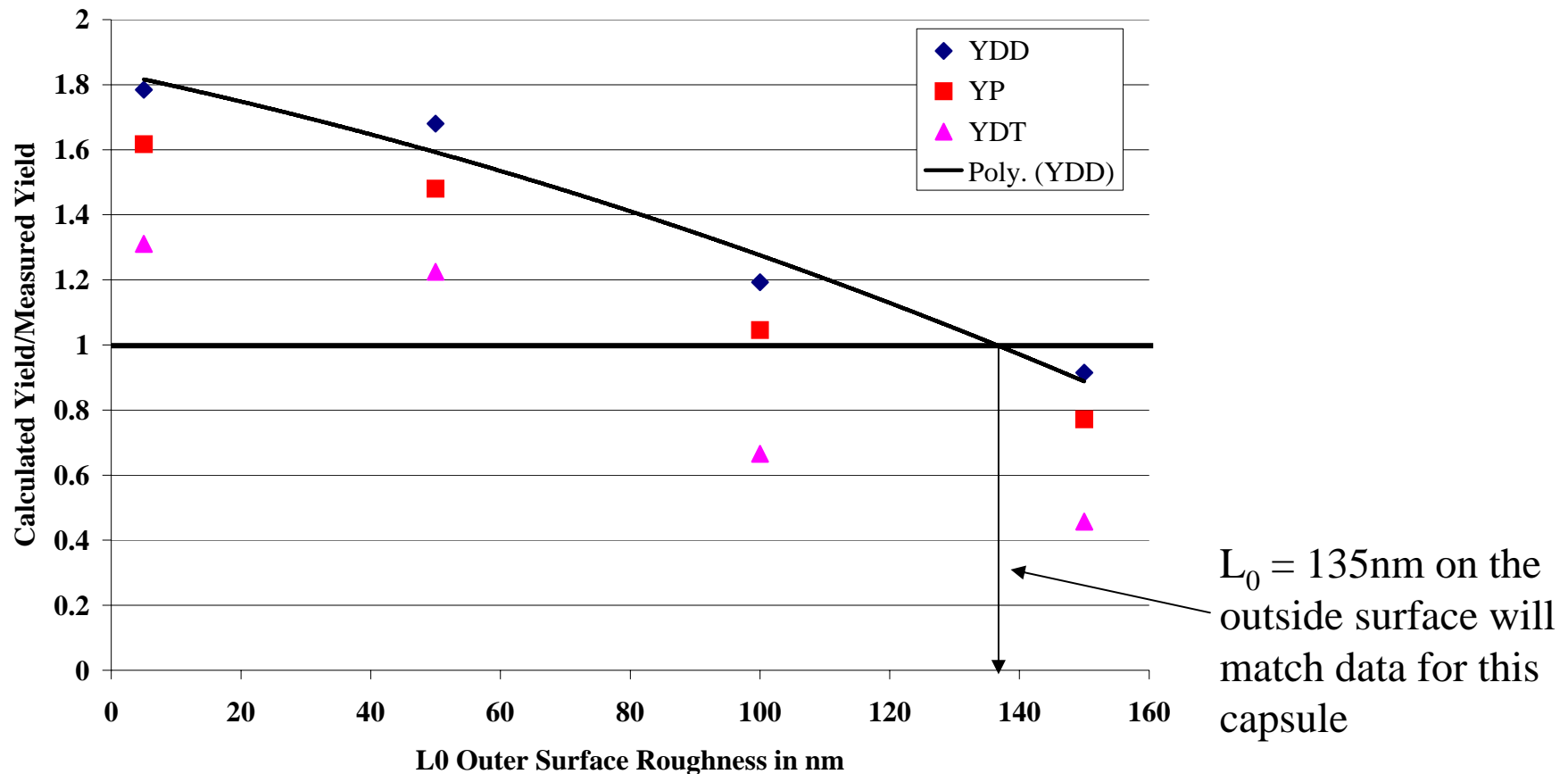


$L_0 = 57\text{nm}$ on the outside surface will match data for this capsule

A surface roughness of 50-70nm gives good results for most capsules however, some require 150nm



L0 Study for Shot 32316

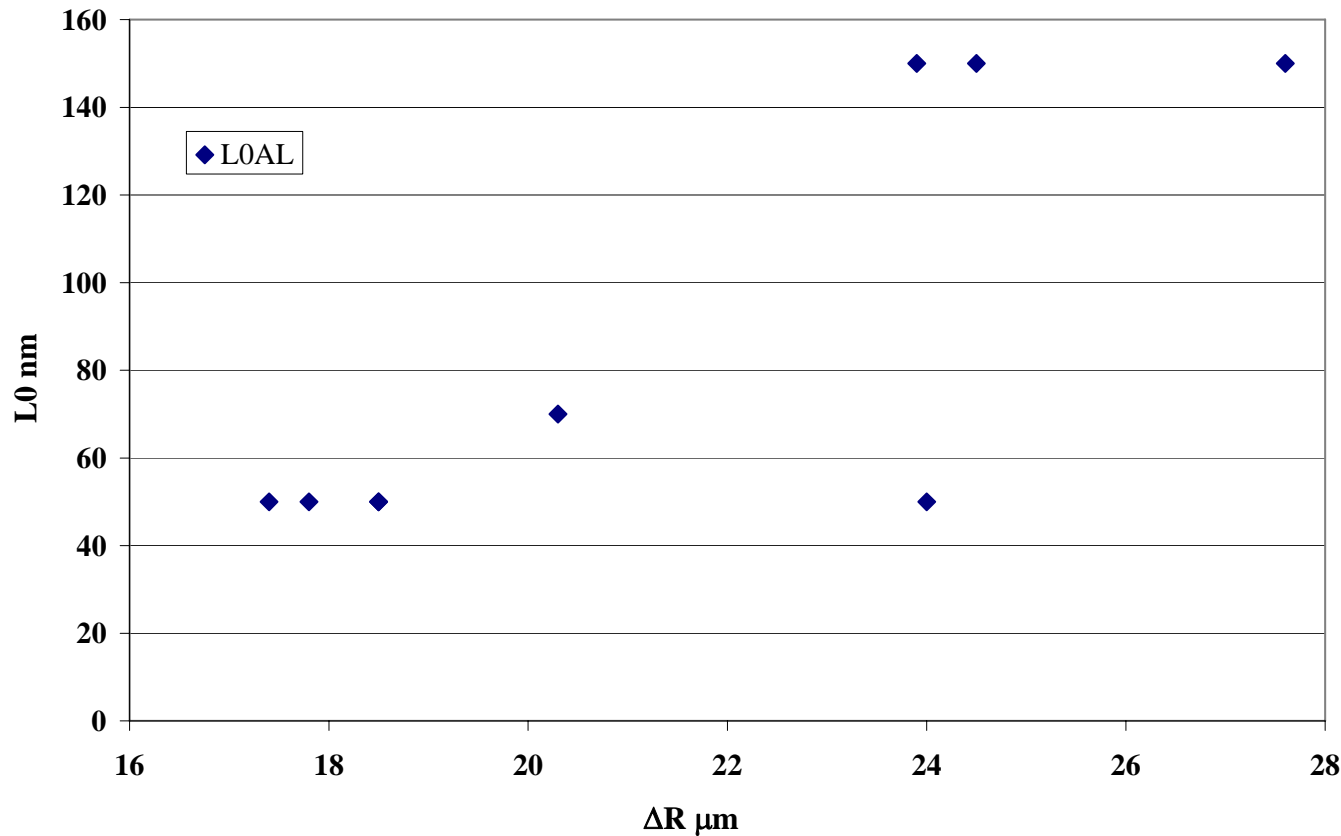


Thin capsules need $L0 = 50$ nm

Thick capsules need $L0 = 150$ nm



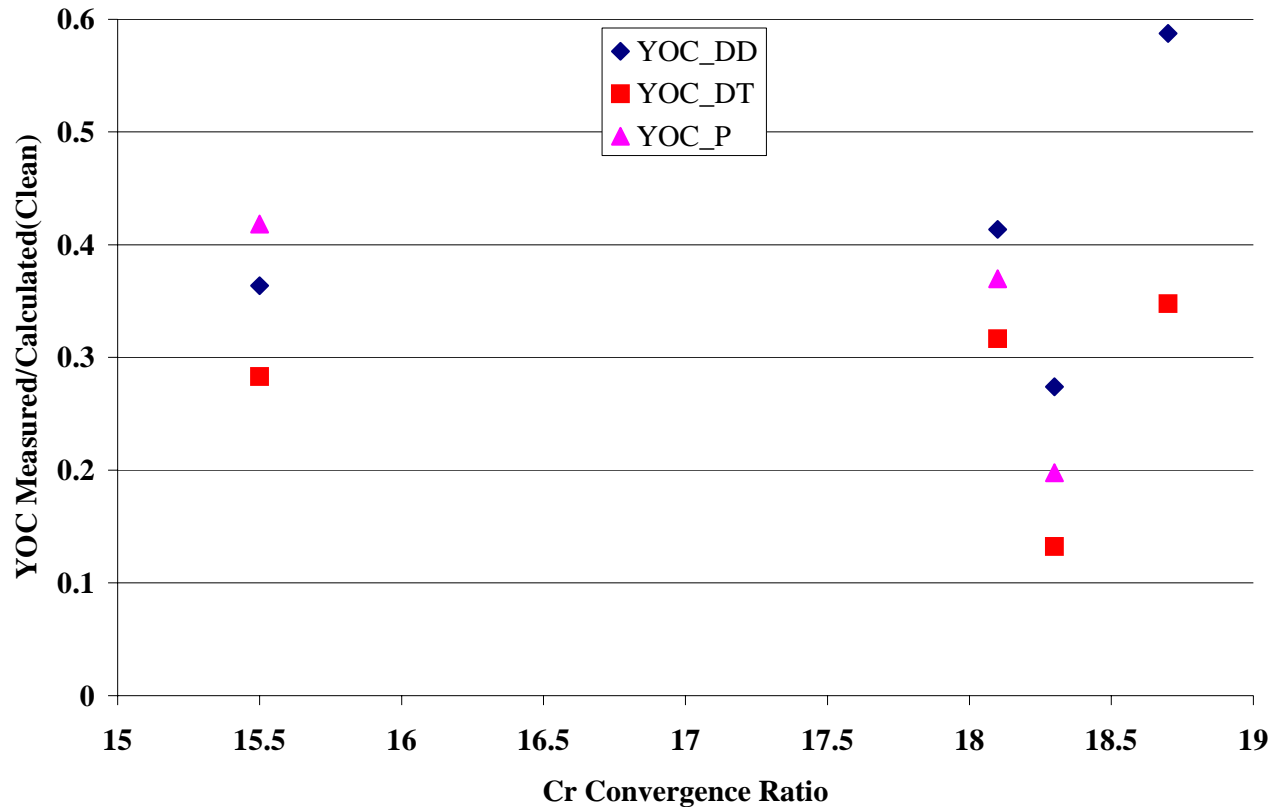
Wall Thickness Study



Y_{DD} from D_2/CH Capsules gave $YOC(\text{Clean}) \sim 0.3\text{-}0.6$



D2/CH Capsules YOC Measured/Calculated(clean)

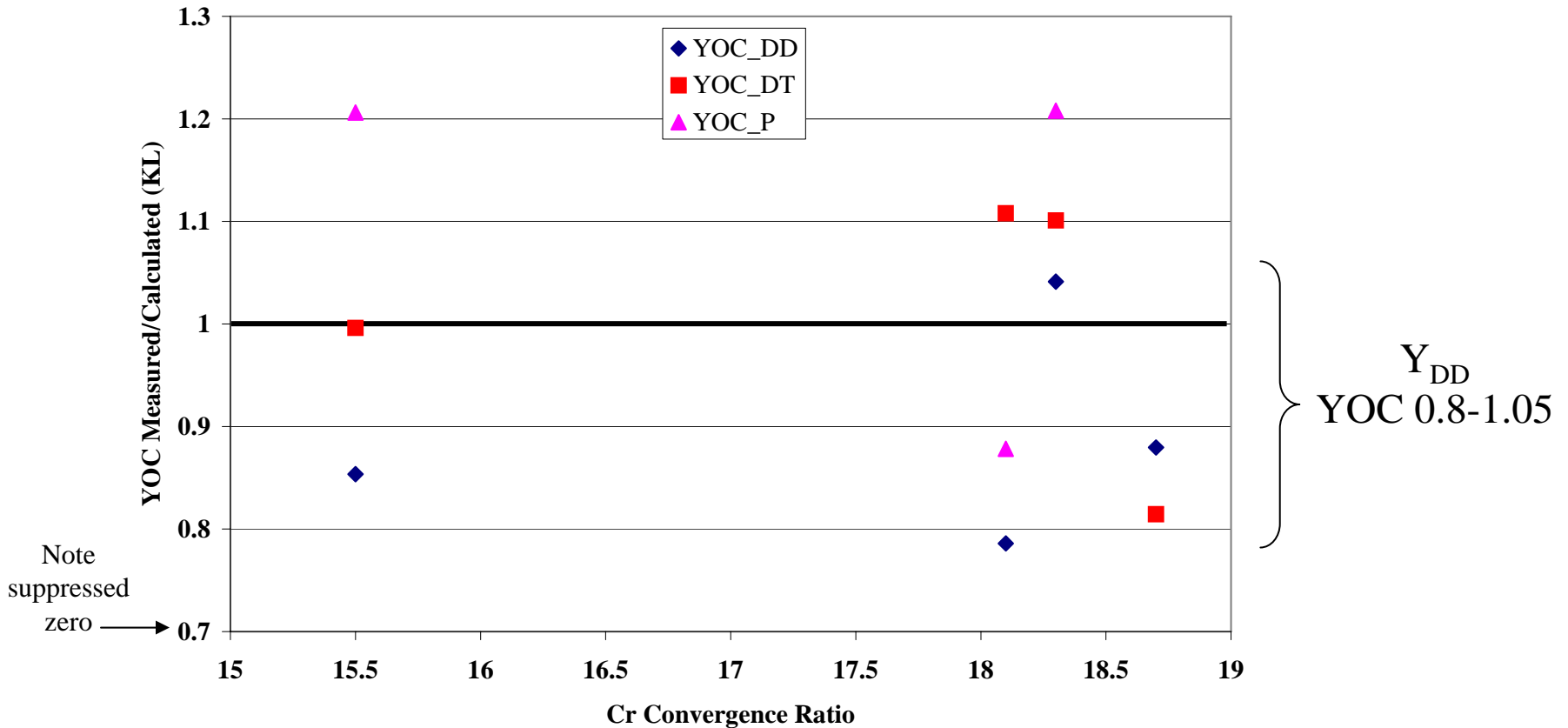


Y_{DD}
YOC 0.3-0.6

Y_{DD} from D_2/CH Capsules gives $YOC(KL) \sim 0.8-1.05$



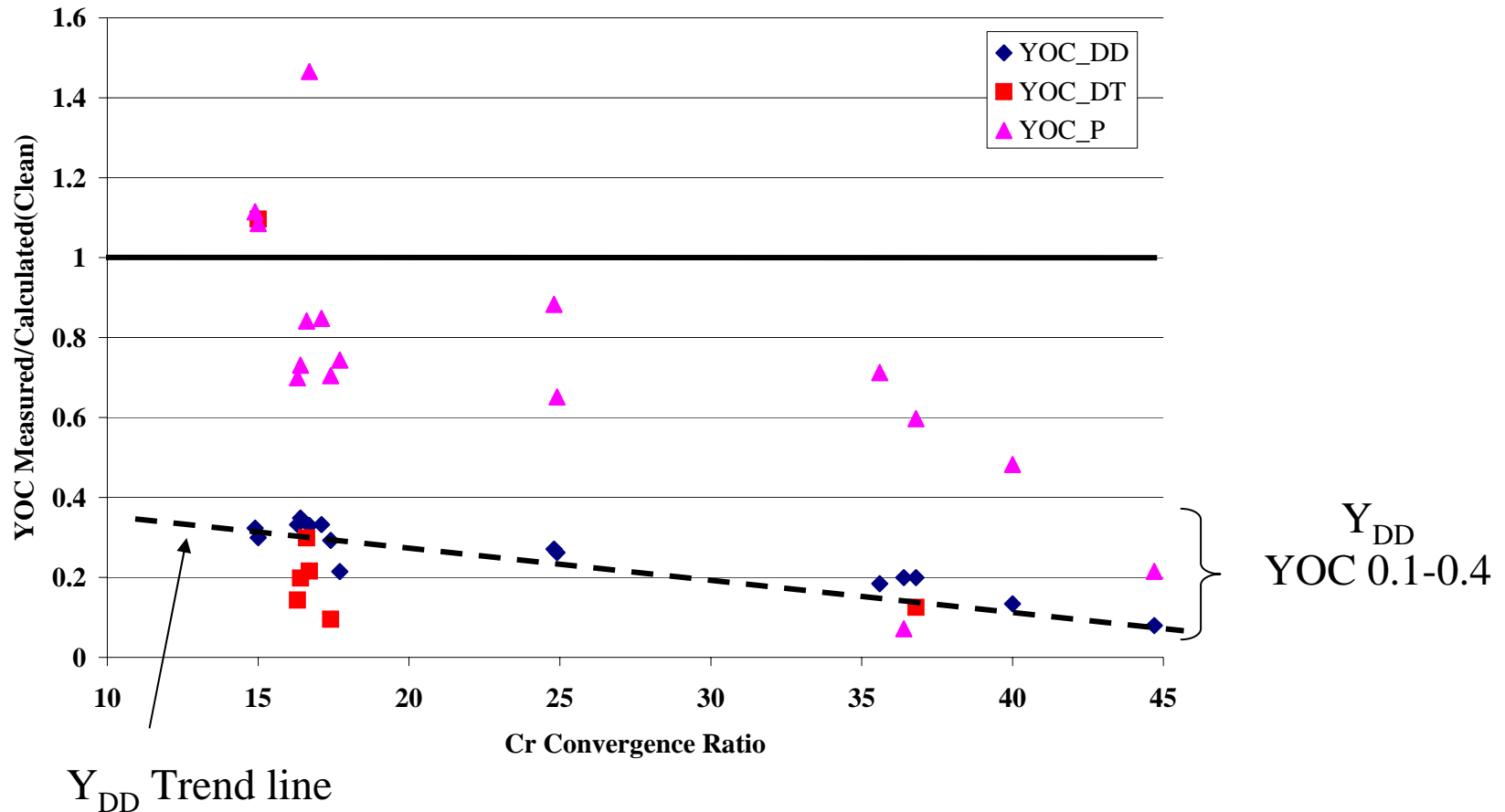
D2/CH Capsules YOC Measure/Calculated(KL)



Y_{DD} from DHe³/CH Capsules gave $YOC(\text{Clean}) \sim 0.1\text{-}0.4$



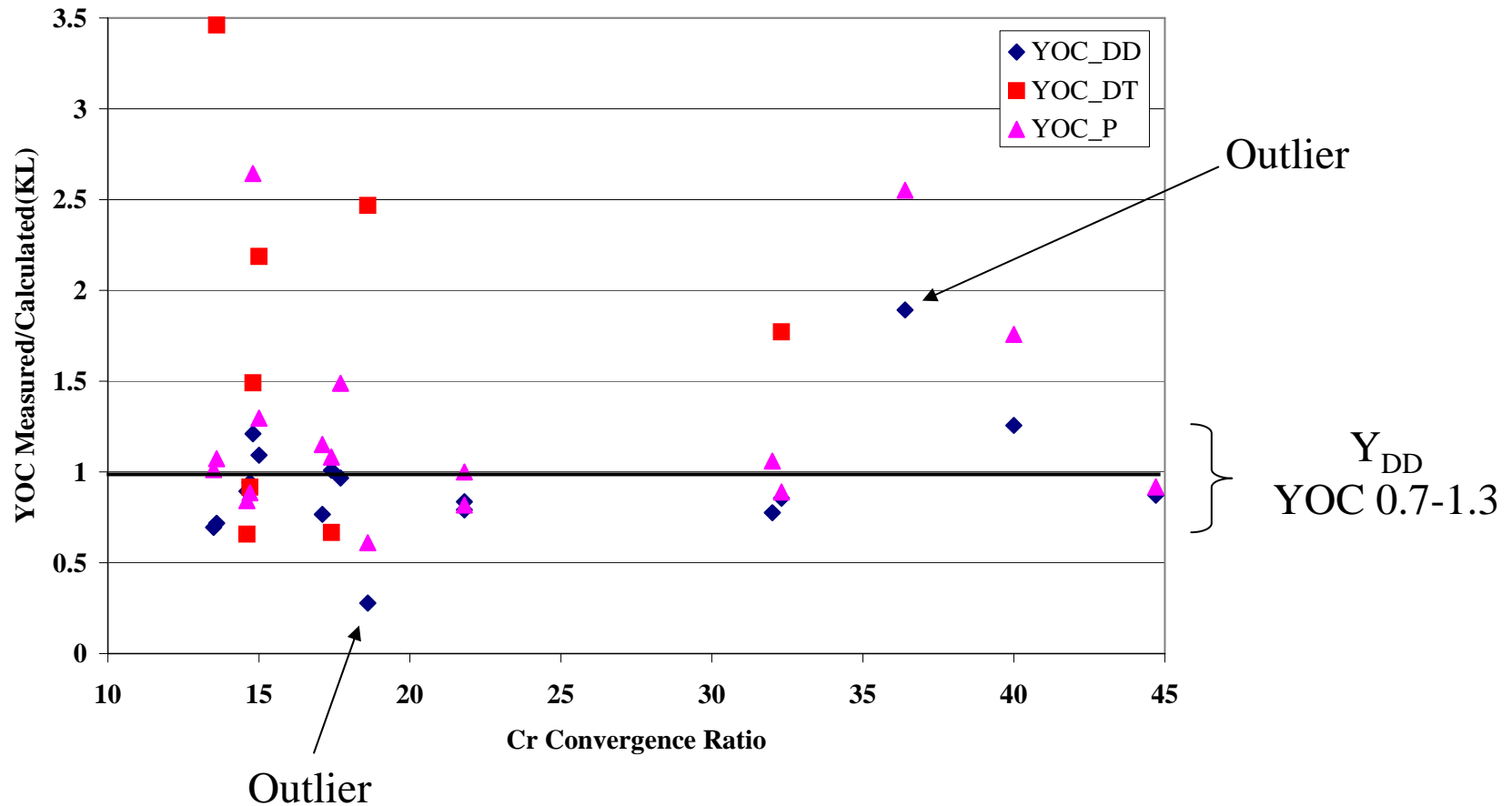
DHe3/CH Capsules YOC Measured/Calculated (clean)



Y_{DD} from DHe³/CH Capsules gives YOC(KL) \sim 0.7-1.3



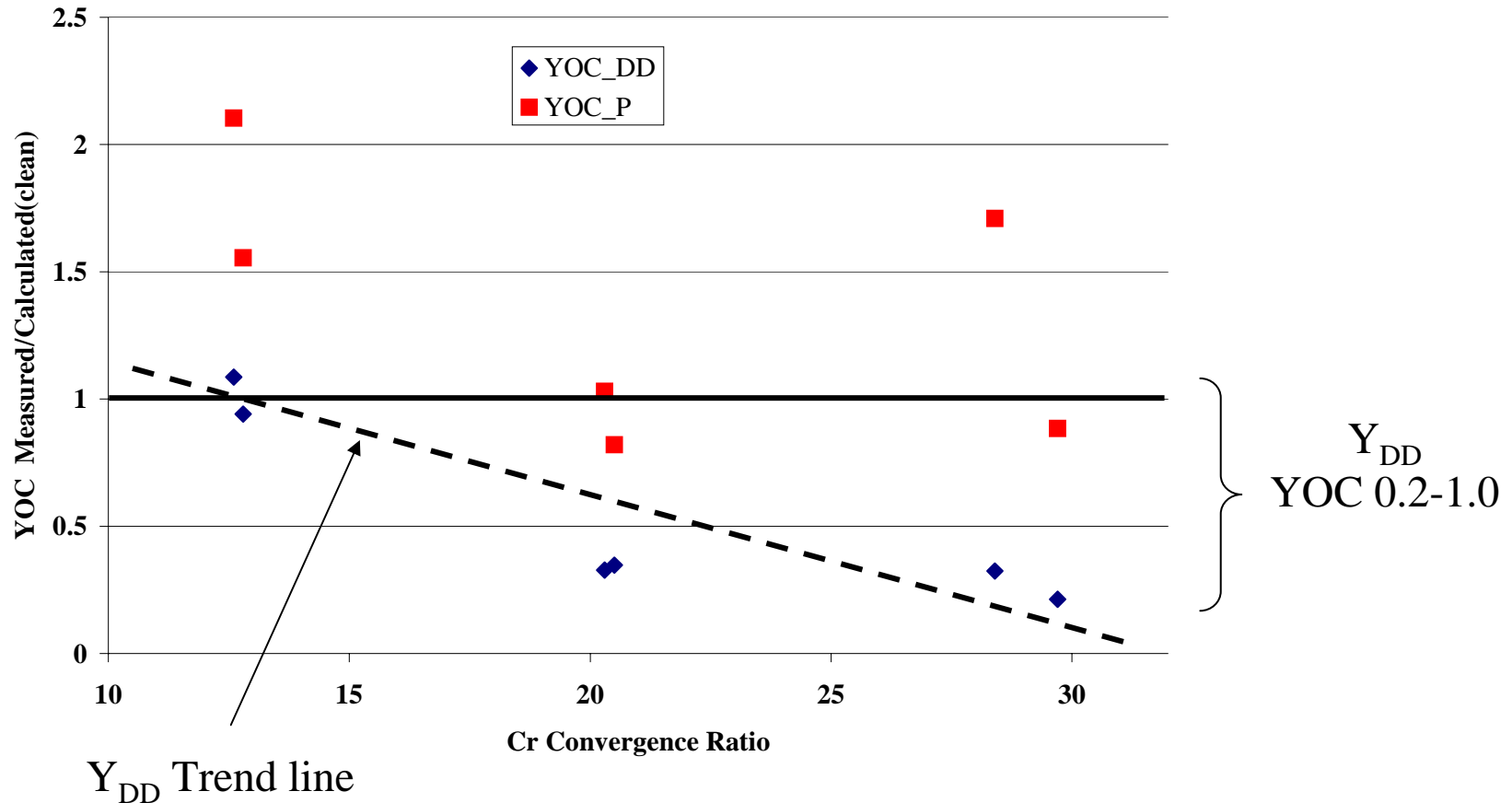
DHe3/CH YOC Measured/Calculated(KL)



Y_{DD} from DHe^3/SiO_2 Capsules gave $YOC(Clean) \sim 0.2-1.0$



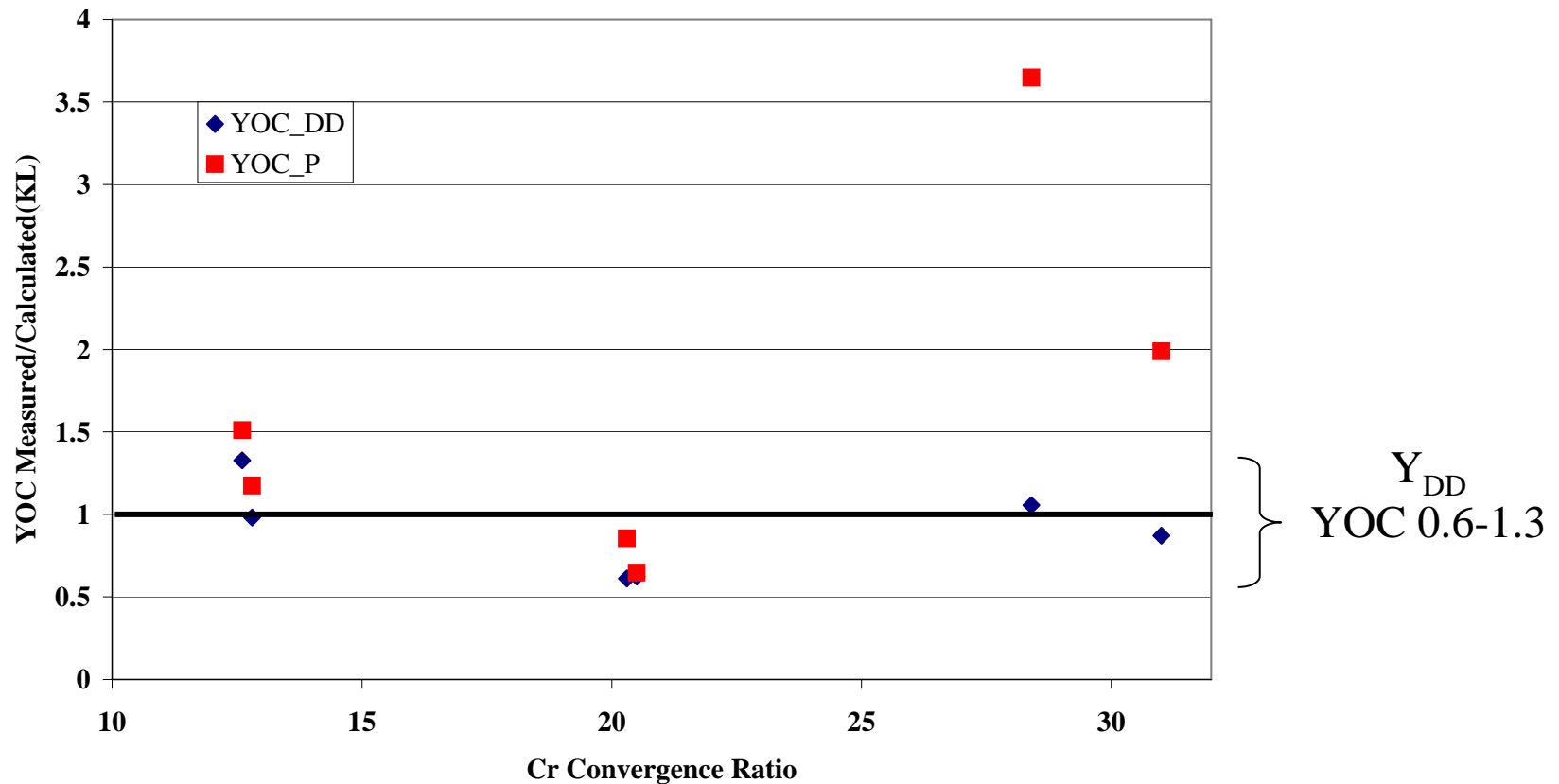
DHe3/SiO2 Capsules YOC Measured/Calculate(clean)



Y_{DD} from DHe3/SiO₂ Capsules gave YOC(KL) ~ 0.6 -1.3



DHe3/CH YOC Measured/Calculated(KL)



Summary



- The coefficients of the KL mix model were set by Dimonte to match RT and RM instabilities as measured on the Linear Electric Motor (LEM).
- The KL mix model has been applied to directly-driven capsule implosions with a variety of laser energies, ablator materials, ablator thicknesses and convergence ratios.
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